INTERNATIONAL RICE COMMISSION

NEWSLETTER

Vol. VI, No. 1 March 1957

Contents

FOOD AND AGRICULTURE ORGANIZATION
REGIONAL OFFICE FOR ASIA AND THE FAR EAST
BANGKOK THAILAND

THE INTERNATIONAL RICE COMMISSION

The International Rice Commission was established under the sponsorship of the FAO for the purpose of promoting national and international activity in respect of production, conservation, distribution and consumption of rice, except matters relating to international trade. At present it has 26 member governments, namely:

Australia	India	Pakistan
Burma	Indonesia	Paraguay
Cambodia	Iran	Philippines
Ceylon	Italy	Portugal
Cuba	Japan	Thailand
Dominican Republic	Korea	United Kingdom
Ecuador	Laos	United States of America
Egypt	Moxico	Vietnam
France	Netherlands	

The First Session of the Commission was held in Bangkok, Thailand, in March 1949; the Second Session in Rangoon, Burma, in February, 1950; the Third Session in Bandung, Indonesia, in May 1952; the Fourth Session in Tokyo, Japan, in October 1954; and the Fifth Session in Calcutta, India, in November 1956.

For technical matters the Commission has special working groups. At first the Commission began with two working parties — one on rice breeding and the other on fertilizers — organized in 1950 and 1951 respectively. In 1954 the Commission added three more working groups to work on the topics of rice storage and processing; mechanization of rice production; and soil-water-plant relationships in the production of rice.

RATIONALISATION OF FERTILIZER USE THROUGH EXPERIMENTS ON CULTIVATORS' FIELDS

H.N. Mukerjee

Soil Fertility Specialist, Agriculture Division,
FAO Regional Office, Bangkok

CORRECT use of fertilizers is one of the cheapest and quickest methods of increasing crop acre yields. Unfortunately, adequate informations for advising the cultivators on the economic use of fertilizers is not at present available in all the South-East Asian countries. The same situation prevailed in Bihar (India) in 1943. At that time the existing methods of estimating the nutrient needs of soils, through chemical analysis of soils and fertilizer trials on the experimental farms, were unreliable. The results of chemical analysis were interpreted using unreliable arbitrary standards, because correlations between such analysis and the actual crop response in the field had not been established. Furthermore, the soils of the few experimental farms did not represent the cultivators' soils even across the fence, because the soils of the experimental farms had received better management and were affected by the residual effects of many years of fertilizer applications, supply of irrigation water, etc. Most of the cultivators' soils had received neither good management nor fertilizers, nor were they assured of a good supply of irrigation water. Hence the results of field trials carried out on the experimental farms could not possibly be reproduced under the cultivators' conditions.

These circumstances led the author to submit to the Government of Bihar in 1943 a scheme of investigation, the main features of which are as follows:—

1. To obtain reliable informations for advising the cultivators, a series of extensive fertilizer tests should be undertaken under conditions, which are comparable to those prevailing in the cultivators' fields.

2. For this purpose trials should be of a very simple design and should be extensively scattered at random to include all the different soil-water regimes existing in the state.

3. The results of these trials should be correlated with the soil types, classified according to modern concepts, and also with the chemical analysis of the soils.

Financial authorization for this scheme was delayed and work did not start until 1948. The Working Party on Fertilizers of the International Rice Commission has also been emphasising the desirability of adopting the above technique (10, 11, 12, 13) since 1951. In 1953, the following recommendation was made:—

"The necessity of a large number of trials of a simple design that need not give a highly accurate characterisation of the soil at a particular location, suggests immediately

the possibility of using simple cultivators' trials, unreplicated at each location, but being capable of statistical analysis for examination from the local and regional point of view by virtue of replication from place to place. The value of large numbers of these simple trials as demonstrations is another major advantage in their use".

Since 1953, most countries in the South-East Asian region have started experiments on cultivators' fields, but excepting India, Burma and Malaya, the above technique of simple randomised trials, has not yet been adopted. Usually, in the other countries, only one 'representative' site is arbitrarily selected within the boundary of a soil unit and one replicated complex trial, having from 25 to 60 sub-plots, is conducted. This trial is then continued for 3 years, in order to assess the effects of the seasons. Such a technique cannot supply reliable information for advising cultivators. If correct advice is to be given, an extensive series of simple tests, scattered at random on fresh sites every season, within a soil unit, should be undertaken (1, 2, 9, 16).

Over 20,000 such experiments have been carried out by the author and his co-workers in Bihar (India). Some of the results have been published (3, 4, 5, 6, 14, 15, 17), but a summary of the technique followed and the nature of results obtained are presented below.

Bihar Fertilizer Tests on Cultivators' Fields

The objective of these tests was to obtain reliable information for advising cultivators on the economical use of manures and fertilizers. The tests were planned in 1943 and started in 1948.

Scope Bihar State has an area of 73,000 square miles. In the absence of a modern soil survey map, the state was divided into 150 'homogeneous' soil units, on the basis of available soil information. These units were used as a basis for determining the fertilizer requirements. When an accurate soil survey map becomes available, the results will be re-allocated to soil types.

Organisation One field assistant was posted in each of the 150 soil units. In addition, there were about 40 other staff for supervision, soil analysis, office work, etc. It was found by experience that the experiments could be carried out under stricter control, if the field assistants were placed under the supervision of the local extension officers, and an over-all control maintained by the supervisory staff of the scheme.

Number Each field assistant carried out six experiments on a particular crop and a total of thirty experiments on 5 crops during a year.

Distribution of tests For each crop, three villages were selected *at random*, within an area of 200-300 square miles representing an area of 5-7 miles radius, around the headquarters of the field assistant. The boundaries of the area to be sampled and within which the villages were randomised, could coincide with those of a soil or administrative unit. Two plots were selected *at random* in each village in order

to give six replicates of the experiment. The random selections of villages and fields were made in the statistical laboratory and communicated to the assistants in the field. A few more villages and fields than necessary were selected, so that if in any village or field the crop was not being grown or the cultivators were unwilling to cooperate, the experiment could be shifted to the next village or plot on the list.

Experimental layout The selected cultivators' plots were divided into a number of sub–plots of 1/10th acre each, depending on the design of the experiment. In undulating hilly areas, sub–plots of 1/20th acre were used. It is however possible to divide the whole of a cultivator's plot into the required number of sub–plots of any size, and apply the calculated amounts of fertilizers. But experience showed that this introduced additional calculations at each site and consequent sources of error with low–paid staff. Hence standard plot dimensions of 1/10th or 1/20th acre were used, wherever possible. In the first year only 4 sub–plots were attempted, in the second year 6 and in the third year 7. It was however found that the laying out of 6 sub–plots per experimental site was most convenient to handle by the field assistants in the initial stages of the work. After the assistants were experienced, they were able to handle quite satisfactorily even 10 to 12 sub–plots per site. It is however advisable to keep the numbers of sub–plots close to 6.

Treatments and designs Although experiments have been conducted on 13 important crops of Bihar, as an example only the treatments used with paddy are presented. The figures refer to plant nutrients in lbs. per acre.

1948–49 – O, 20 N, 30 N, 40 N

1949–50 – O, 20 N, 30 N; 40 N; 30 N + 37.5 P_2O_5; 30 N + 25 $P_2O_5{}^x$

1950–51 – O, 40 N; 40 N + 40 P_2O_5; 40 N + 40 $P_2O_5{}^x$; 40 N + 8 $P_2O_5{}^x$, 40 N + 28 $P_2O_5{}^x$, 40 N^x

1951–52 – O, 40 N, 60 N; 40 N + 40 P_2O_5; 60 N + 40 P_2O_5; 60 N + 40 $P_2O_5{}^x$

and O, 40 N, 60 N; 40 N + lime; 40 N + 40 P_2O_5 + lime, 60 N + 40 $P_2O_5{}^x$ – for acid soils

1952–53 – O; 30 N + 20 P_2O_5; 40 N + 20 P_2O_5; 40 N + 40 P_2O_5; 40 N + 40 P_2O_5 + 40 K_2O; 47 N + 50 $P_2O_5{}^x$

and O; 40 N + 20 P_2O_5; 40 N + 40 P_2O_5 + lime; 40 N + 40 P_2O_5; 40 N + 40 P_2O_5 + 40 K_2O; 47 N + 50 $P_2O_5{}^x$ – for acid soils.

---

^{x} *Indicates treatments where parts of N and and P_2O_5 were supplied through cheap indigenous sources, e.g., compost, oilcake and bonemeal.*

All the above treatments were tested at each site with replications on different sites, as explained above. After sufficient preliminary information was obtained on the effects of the various treatments, a different design of experiment was adopted during 1953-54, which was repeated for three years till 1955-56. In this design, instead of repeating only six treatments in 36 sub-plots in 6 sites, 15 treatments were introduced in six types of experiments, each of which was laid out at one site. Thus with the same 36 sub-plots at six different sites as before, it was possible to obtain information on 15 different treatment combinations. The designs of these experiments were as follows:—

Type 1:	O	N_1	N_2	N_1P_1	N_1P_2	$N_1P_1K_1$
Type 2:	O	N_1	N_2	N_1P_1	N_1P_2	N_1K_1
Type 3:	O	N_1	N_2	N_2P_1	N_2P_2	$N_2P_2K_2$
Type 4:	O	N_1	N_2	N_2P_1	N_2P_2	N_2K_2
Type 5:	O	N_1	N_1P_1	$N_1P'_1$	$N_1P'_1K_1$	$N_1P'_1K_2$
Type 6:	O	N_1	N_1P_1	$N_1P'_1$	N_1K_1	N_1K_2

Where P_1 = 20 lb. P_2O_5, P_2 = 40 lb. P_2O_5, P'_1 = 20 lb. P_2O_5 as bonemeal, P'_2 = 40 lb. P_2O_5 as bonemeal, N = 20 lb. N, K = 40 lbs. K_2O, per acre.

It can be seen from the above that through suitable designs it is possible to test a large number of treatments, without increasing the amount of experimentation and costs.

From 1956, the above method of designing experiments was further extended and NPK experiments of 3^3 designs, with three blocks in a replicate and with higher order interactions confounded, have been undertaken, with 9 of the treatments in each block, located at a particular site, and three such sites located at random in a village. Different doses of N, P and K from 25 to 50 lbs. per acre are being tested in different soil zones, on the basis of past results obtained in those areas. It is possible to carry out such detail experiments in large numbers now, because the field assistants after eight years of work under cultivators' conditions are able to control properly the trials.

Plot technique After laying out the plots, the treatments meant for the particular site were allocated to different sub-plots, strictly at random, by independent randomisation at each site.

Fertilizers were applied at the time of sowing for dryland crops and between two and three weeks of transplanting for paddy

This has given best results in 'time of application' experiments in the past, but separate placement experiments are in progress for introducing, if necessary, any modifications in present practice. Records of heights and tiller counts of random plants in each treatment were kept. A profile pit was examined at the experimental sites in different soil types and records maintained on 'soil survey record sheets'. Samples of soils were sent to the laboratory for correlation studies between chemical analysis and crop response.

The whole of the crop in each sub-plot of 1/10th or 1/20th acre was havested, dried, threshed and weighed. Although it would be satistically quite sound to harvest only an area of 1/50th or 1/80th of an acre from the centre of each sub-plot, yet it has been found better to havest the whole sub-plot, in order to avoid additional manipulations in a thickly growing crop. In addition, when larger quantities of produce from each treatment are weighed in presence of the cultivator, this gives him a much better idea of the efficacy of particular treatments.

Statistical analysis of data The data obtained were statistically analysed by pooling together relevent figures to supply information on the fertilizer interactions with various factors such as administrative units, soils units, the geology of the area, irrigation practices, etc. Information was also derived on the fertilizer interactions with a combination of factors such as soil texture and geology of the area on soil texture and irrigation, etc. For estimating the responses to a particular treatment, say 25 lbs. N per acre, if this treatment has been tried in more than one type of experiments in the 1953-54 design, estimates from different types of experiments were combined to get a pooled estimate. The estimates were combined using the number of experiments in each type as weights. Experiments under each of the types were grouped together separately for purposes of analysis. Analysis of variance was performed on a random sample of two experiments per district (administrative unit) per type. For the purposes of obtaining standard errors of various responses, values of S_1^2 and S_2^2 from different types of experiment in the analysis of variance, were pooled together. The results were finally tabulated into a number of tables showing the mean responses to different treatments and individual responses to N,P,K, bonemeal, etc., under different soil conditions, such as geology, texture, irrigation, etc. A separation of the responses according to gradually diminishing sizes of administrative units such as districts, sub-divisions and thanas were also worked out for advising the extension workers in these areas.

Controlling the accuracy The accuracy of the experiments were controlled by a series of checks. The field assistants' work was directly supervised by local extension inspectors at the time of laying out of plots, application of the fertilizers and the harves-

ting and weighing of grain. A number of random plots were also checked by higher extension officials such as subdivisional agricultural officers, districts agricultural officers and the deputy directors of agriculture. These checks were in addition to the control exercised by the supervisory staff of the "scheme for simple fertilizer experiments" and by the cultivators who were required to sign certificates to the effect that the experiments were carried out properly on their plots and that the reports of results were received.

Costs involved Only the fertilizers were supplied free to the cultivators for these experiments. All work in connection with these experiments, viz., construction of bunds, transporting of fertilizers from depots, harvesting, threshing, weighing, etc., were carried out by the cultivators without any extra remuneration. Difficulty in cooperation was experienced in the first season, but as soon as the good effects of the fertilizers were apparent, all cultivators were only too willing to cooperate in these experiments, in return for the free supply of fertilizers. After a few seasons, the cultivator is also willing to pay for the fertilizers, to ascertain the correct fertilizer needs of his soil, through a properly conducted test. Many such experiments at cultivator's expense have been conducted in Bihar. The field assistants, who carried out these experiments, were recruited from high-school trained candidates and hence did not cost much. These men after some preliminary training and practical experience in the field under senior staff turned out to be excellent workers.

Total numbers of experiments Since 1948, about 20,000 simple randomised tests have been carried out in Bihar on different crops, viz., paddy (Oryza sativa), wheat (Triticum vulgare), maize (Zea mays), gram (Cicer arietinum), rahar (Cajanus indicus), peas (Pisum sativum), masoor (Lens esculenta, Mocuch), kheshari (Lathyrus sativus), potato (Solanum tuberosum), sweet potato (Ipomea batatus), tobacco (Nicotiana tabacum and N. rustica), chillies (Capsicum annuum), jute (Coreborus capsularis and C. Olitorius), etc.

Results of significance From the nature of the experiments described above, it may be inferred that results of great value have been obtained from the 20,000 experiments carried out in Bihar during the last eight and a half years. As mentioned earlier these have been reported in different publications but no detailed discussion is here possible. A few significant points may however be indicated :—

1. The results from the different areas can be used as reliable guides for advising extension workers on the fertilizer recommendations which they should disseminate amongst the cultivators. The table below shows the responses to different nutrients in different areas of one of the 18 districts of Bihar :—

Responses to N, P and K in Different Administrative Units (200 sq. mi.) in Bihar
(Increased yields over no fertilizers, in maunds[1] per acre)
Paddy (1954-55)
District Patna

Sub-Division	Thana (Administrative unit)	No. of experiments	N_1	N_2	P_1	P_2	P'_1	K_1	K_2	Recommendation
Patna	Phulwari	6	3.32	2.97	3.46	1.33	3.95	1.74	2.13	N_1 P_1 K2
	Massaurhi	6	5.89	8.96	0.74	0.85	-0.25	0.95	2.03	N_2 K_2
Barh	Barh	6	5.25	7.18	3.36	1.77	-1.62	0.06	1.51	N_2 P_1 K_2
	Bakhtiarpur	5	6.31	5.56	2.42	4.88	-0.45	-0.21	0.79	N_1 P_2
	Fatuha	6	7.46	8.22	6.00	5.95	-0.62	1.87	4.85	N_1 K_2
Biharsharif	Bihar	6	5.80	6.66	2.85	3.05	1.36	0.13	0.09	N_1 P_1
	Ekangarsarai	6	8.16	8.08	2.82	6.53	-2.11	1.40	1.12	N_1 P_2 K_1
	Geriak	6	3.88	7.01	3.95	6.73	2.33	1.66	2.38	N_2 P_2 K_2
	Silao	5	5.27	5.61	3.34	4.85	1.02	1.73	1.82	N_1 P_1 K_1
Dinapur	Dinapur	6	2.80	2.91	1.64	1.27	1.27	−1.12	0.75	N_1 P_1
	Maner	2	3.87	–	1.47	–	−0.86	0.52	0.42	N_1 P_1
	Naubatpur	6	−0.64	3.00	2.45	2.56	2.12	4.75	2.08	N_2 P_1 K_1
	Bikram	6	3.82	5.01	3.10	5.11	0.17	0.10	0.71	N_2 P_2
	Bihta	6	4.19	6.86	2.72	3.33	4.75	1.17	−0.78	N_1 P'_1 K_1

1 one maund = 82 lbs. approx.

The last column of the table shows the nutrients most needed and their ratios which gave most economic returns. This column clearly indicates that different treatments are profitable in the different areas of this district, and yet there is *only one experimental farm* in the whole of this district. It is therefore obvious that entirely erroneous advice would have been given to the cultivators of this district, if these simple randomised fertilizer tests on cultivators' fields had not been carried out. All the results obtained from the different districts very strongly emphasise the same point, viz., the

economical doses of fertilizers vary enormously within short distances, and it is entirely wrong to advise cultivators on the results of experiments conducted at a few experimental farms.

2. Trials at experimental farms had shown that nitrogen was the main requirement for Indian soils and phosphate was required only on a very small percentage of the soils. The trials on the cultivators' plots showed immediately that the above conclusion about phosphorus was entirely wrong. In Bihar, phosphorus showed economical responses in almost all trials on cultivators' fields and when such tests were conducted on an all-India scale, similar results were obtained.

3. Similarly, as a result of trials on experimental farms, it is still believed in India that potash is not required for cereal crops. The trials on the cultivators' fields in Bihar have clearly shown that the above conclusion is not correct. There are many areas where potash has shown good economical increases in yields and the author believes that when potassium is tried extensively on cultivators' fields all over India, as has been done for phosphorus, many areas will be found where potassium would show economical response on cereals.

4. The results obtained through these trials on cultivators' fields for the phosphorus and potassium requirements of Indian soils led the author and his colleagues in the "Manures and Fertilizer Committee" of the Government of India to fix adequate targets in the Second Five Year Plan for these two plant nutrient elements, in addition to those for nitrogen.

5. It was found that a cheap combination with 20 lbs. N as compost, 20 lbs. N as ammonium sulphate and 40 lbs. P_2O_5 as bonemeal per acre, gave increased yields comparable to the more costly combination of 40 N : 40 P_2O_5 : 40 K_2O as commercial fertilizer. Such cheap combinations would be very profitable to cultivators in countries, where the prices of fertilizers are high and the prices of grains are low, and where the application of straight fertilizer mixtures are not economical.

6. It was found that the possible increase in yields of crops through fertilizer use varied greatly in different areas of Bihar and reliable estimates of these were obtained by these extensive tests. This enabled the author to draw up a plan for making good the food deficit of the state immediately, through application of the proper kinds and doses of fertilizers, on the more responsive paddy lands of the state which comprised only 10 percent paddy area. (3) This type of information is most valuable to the government for national planning.

7. These tests were excellent demonstrations for the cultivators, who started to use fertilizer in areas where they had never tried these before.

8. A soil survey for the classification of soils according to modern concepts was started in 1954 and the results of the above experiments are being correlated with the 'soil types'.

Dissemination of the results Apart from the visual demonstration of these tests, leaflets were printed and distributed to the cultivators through the extension service, giving the names of the cultivators on whose fields experiments had been conducted, the most profitable fertilizer combination found in different areas and the general recommendations for different soil conditions.

Expansion of the scope of the scheme The Government of Bihar had first authorised the scheme as an experimental measure, but because of its proved value, the scheme was steadily expanded and by the seventh year, it was made a permanent project of the Department of Agriculture, under the name of the 'Field Experimental Service'. The principle, finally adopted by the government, was that for reliable results, experiments need to be conducted under cultivators' conditions and that this must not be confined to manures and fertilizers only. All other improvements in agricultural practices, such as improved seed, agronomic practices, plant protection methods, etc., must now be extensively tested under cultivators' conditions, through this organisation. Because consistently of this, the organization is being strengthened.

Complex Experiments

While tests on the cultivators' fields can be carried out, with treatments involving fertilizer applications only, it is difficult to include the more complex treatments dealing with time and method of application of fertilizers, irrigation x manuring interaction, varieties x manuring interaction, etc. It is therefore necessary to confine such more complex experiments on the existing experimental farms, where full control can be exercised. It is however extremely important to select very carefully the plots for these experiments on such farms, to ensure that the past treatments and other conditions on the particular plots do not adversely affect the results of the experiments. As such plots are difficult to find in the existing experimental farms, the Indian Council of Agricultural Research, initiated on an all-India basis in 1953-54 a scheme of "Model Agronomic Experiments". Under this scheme even complex experiments are not conducted on experimental farms. For these complex experiments, 15 acres are rented from the cultivators. A selection is made to represent the major soil units of India and the experiments are carried out on these blocks of land under controlled conditions, similar to the experimental farms. The following experiments are being conducted on these 15-acre blocks, since 1953-54, on paddy :—

1. Levels of different forms of N and P fertilizers.
2. Time of application of the different kinds of N fertilizers, with applications including split applications at different stages of the development of the plant.
3. Fertilizer placement including broadcasting and drilling at puddling time, dipping the plant roots in fertilizer slurry and the pellet method.

4. Liming of paddy soils.
5. Residual value of phosphates.
6. Irrigation frequencies and fertilizer effects.
7. Variety x fertilizer interactions.
8. Levels of N + P + bulky organic manure.
9. Efficiency of different types of N fertilizers.
10. NPK experiment in the 3^3 design.
11. Effects of trace elements.

Similar experiments are also being carried out on other crops.

The above list of items are by no means exhaustive and different countries might be interested in other items which would be of use to their cultivators, e.g., effects of fertilizers in a rotation and in soil conservation practices; physiological diseases; nitrogen-fixation through azotobater; legumes and blue-green algae; use of anhydrous ammonia; plant population and rate of fertilization; treatment of seeds with plant nutrients; effects of Fe, Mg, Si, etc.; phosphate fixation; nursery manuring; correction of salinity and aluminium toxicity; effect of ploughing under a portion of the straw in the field; soil conditioners; etc. It is necessary however to test these under controlled conditions on soils representative of those of the cultivators' fields before any sound recommendations are possible.

Correlation of Chemical Soil Analysis with Crop Response to Plant Nutrients

Simple fertilizer tests at random on cultivators' fields can only indicate *average* nutrient requirements of soils. Individual cultivators would however require more specific advice, for their own plots, which can be only given to them, if the quicker method of chemical analysis of soils is adopted. The results of chemical analysis of soils cannot however be interpreted properly unless correlations are established between such analysis and the actual crop response on different soil units. Such correlations have been established in some countries, where sound advice is being offered to the cultivators, on the basis of the chemical analysis of their soil samples. Unfortunately, sound correlations on the above lines have not as yet been developed for most of the South-East Asian countries, and it is recommended that the soils from the extensive series of simple fertilizer tests on cultivators' fields should be chemically analysed, with the object of developing such correlations.

Unfortunately, good correlations are not generally obtained by the usual methods of analysis. For satisfactory results, special methods of analysis and soil sampling are necessary. In the United States of America, Olsen's method for available phosphorus determination with sodium bicarbonate extraction has been found to correlate far better with crop response than other methods and the same has been observed by the author and his co-workers (7) in Bihar and also by the workers at the Indian Agricultural Research Institute in Delhi, India. In the case of potassium, the author and his co-workers have found that the percentage of potassium-saturation of the

exchange complex correlates better with crop response than other criteria. (8) The Working Party on Fertilizers of the International Rice Commission in its meetings held in 1952, 1953, 1954 and 1955 has been recommending the adoption of more rational procedures for soil sampling and soil analysis. It has been recommended that for proper understanding of the situation, paddy soils should be analysed under submerged and unoxidised conditions, as they are found in the field during the period of active growth of paddy. The following recommendations of the above Working Party (13) during its 1955 meeting, indicate very clearly the directions in which work should be undertaken, in order to collect data for establishing satisfactory correlations between the chemical soil analysis and the expected crop response to different plant nutrients:—

"1. Countries conducting formal field fertilizer trials, either complex or simple tests on cultivators' fields or both, should make an effort to obtain soil samples at least representative of the top 15 cm. of soil from as many sites as possible.

"Analytical methods already adopted by the respective laboratories are suitable for the initial evaluation of soil test results compared with field fertilizer response, so long as the methods include at least pH, exchangeable H, total or easily oxidised organic matter, exchangeable or easily soluble P, K, Ca and Mg. Sulphur determinations are desirable in certain areas where "black root" is observed, and easily reducible manganese and iron, soluble aluminium, conductivity and phosphorus absorption capacity should be determined, if at all possible.

"2. In conjunction with the soil test data, foliar data, namely, foliar analyses on fertilizer test plots should be attempted in light of the French results, including at least measurements of N, P and K in panicular leaves.

"3. Since information is still limited concerning concentration of soluble elements in soil solutions of submerged soils, fundamental chemical studies of submerged soils should be promoted with particular emphasis on the possibilities of toxic concentration of reduced elements and their inter-relation, as well as with other essential elements within the rooting zones."

Concluding Remarks

Excepting Japan, Taiwan and Korea, the use of fertilizers on food crops in the other countries of South-East Asia is very limited. In the interest of greater food production to meet the needs of the growing population, and to make the individual cultivator more prosperous through more efficient crop production, it is necessary to promote fertilizer use in this region. For this purpose, the first essential is to offer sound advice to the cultivators on the economical use of fertilizers. It is possible to offer such advice, only if the steps indicated above are taken, viz., (i) extensive simple fertilizer tests on cultivators' fields, (ii) complex agronomic experiments on soils representative of cultivators' conditions, (iii) correlation of the above results

with soil classification according to modern concepts and (iv) correlation of the chemical analysis of soils with the field fertilizer responses. If sound advice is made available to the workers of an active extension service, for dissemination through field demonstrations, pamphets, lectures, cinematographs, etc., then a rapid promotion of fertilizer use would be assured. It is however the experience in some countries, that even when a substantial increase in crop yield is obtained through fertilizer application, yet due to an adverse fertilizer/crop price relationship between the fertilizer and the produce, the use of fertilizers is not profitable. Such cases usually arise when the fertilizer has to be imported at a high cost. To remedy this situation, it is very important to take steps to make fertilizers available to the cultivators at 'profitable' prices, and to encourage the use of indigenous materials such as crop residues, bones, phosphate rocks, etc. Even when the prices of fertilizers are fairly low, many cultivators are unable to spare the cash for their purchase. To meet this contingency many governments are offering fertilizers on credit. All these steps would help to make the cultivators of this region fertilizer-conscious and consequently more prosperous.

Summary

1. It has been shown that results of experiments on the existing experimental farms are unreliable for advising cultivators about the economical use of fertilizers.

2. Sound advice on fertilizer use can only be given by conducting simple and complex tests under cultivators' conditions, and correlating the crop responses, with soils classified according to modern concepts and also with the chemical composition of the soils.

3. In addition to sound advice, it is necessary to promote the use of fertilizers, through demonstration, propaganda and the supply of cheap fertilizers to cultivators, even on credit, if necessary.

Literature Cited

1. FAO Background Paper: Experimental designs for response curves, IRC/FP/54/1, pp. 1-16, 1954.

2. Hopp, H.: A guide to extensive testing on farms in 3 volumes. Foreign Agricultural Service of the U.S. Dept. of Agriculture, pp. 1-27, 1-69 and 1-36.

3. Mukerjee, H.N.: Soils of Bihar and a new method of determining their manurial requirements. Proceedings of the Bihar Academy of Agricultural Sciences, 1, pp. 58-94, 1952.

4. Mukerjee, H.N.: Showing the manurial way to high yields. Indian Farming, 1, pp. 9-11, 1952.

5. Mukerjee, H.N. and Sinha, P.: Potash response in Bihar soils. Proc. Bihar Academy of Agrl. Sci., 2, pp. 146-152, 1953.

6. Mukerjee, H.N.: Potash response in supposed unresponsive soils, determined by a new technique of experiments on cultivators' fields. Potash Symposium Report, International Potash Institute, Berne, pp. 260-291, 1955.

7. Mukerjee, H.N., Mandal, S.C. and Banerjee, B.S.: Studies on the availability of soil phosphates and better utilization of fertilizer phosphates, by various methods. Proc. Bihar Academy of Agrl. Sci. 4, pp. 86-96, 1955.

8. Mukerjee, H,N., Mandal, S.C. and Mukherji, B.D.: Potash needs of Bihar soils, Proc. Bihar Academy of Agrl. Sci., 4, pp, 1-3 1955.

9. Panse, V.G. and Sukhatme,: Simple experiments on cultivators' plots, Journal of the Statistical Society of India, 1953.

10. FAO Report of the 1st Meeting of the International Rice Commission's Working Party on Fertilizers, pp. 1-18, 1951.

11. FAO Report of the 3rd Meeting of the International Rice Commission's Working Party on Fertilizers, pp. 1-46, 1953.

12. FAO Report of the 4th Meeting of the International Rice Commission's Working Party on Fertilizers, pp. 1-48, 1954.

13. FAO Report of the 5th Meeting of the Working Party on Fertilizers of the International Rice Commission, pp. 1-45,1955.

14. Sinha, P.: Crop responses to added fertilizers in cultivators' fields — A technique for finding out manurial requirements of Bihar soils, — District Patna — Journal of Water and Soil Conservation in India, 3, pp. 97-105, 1955.

15. Sinha, P.: Crop responses to added fertilizers in cultivators' fields — District Shahabad. Journal of water and Soil Conservation in India, 4, pp. 124-130, 1956.

16. Stewart, A.B.: Soil fertility investigations in India with special reference to manuring, Indian Council of Agricultural Research Publication, pp. 1-160, 1947.

17. Yates, F., Finney, D.J. and Panse, V.G.: The use of fertilizers on food grains, Indian Council of Agricultural Research, Research Series, 1, pp. 1-20, 1953.

RICE BREEDING INVESTIGATIONS IN CALIFORNIA[1]

Joseph R. Thysell[2]

Commercial rice production in California began in 1912, when 1,400 acres were sown. In 1954, the area under production was approximately 460,000 acres. The crop is grown largely on the heavy clay and clay-adobe soils in the Sacramento and San Joaquin valleys.

The climate of the interior valleys is hot and dry in the summer, with rain in the fall, winter and spring. During the late summer when rice is flowering, the day temperatures are high but the nights are cool. Pollen tube growth is inhibited when the temperature is below 50°F., and excessive sterility may then occur. Delayed maturity caused by late seeding, excess fertilizer or late-maturing varieties increased the hazards of loss from sterility caused by low temperatures. Late rains in the spring often delay preparation of the seedbed and in certain years early rains in the fall greatly hamper harvest operations. A variety, to be adapted under these climatic conditions, must mature in 155 days or less after sowing. This means that about 170 days are available between the beginning of seedbed preparation and rice harvest. Most of the rice-growing areas of the world have a longer season.

Breeding experiments are needed to develop varieties that are adapted, that do not lodge, have the desired milling and cooking quality, and produce high yields. Such varieties help to insure an equitable return on the large investment in land and equipment necessary for rice production. The Caloro, Calrose, and Colusa varieties, released by the Rice Experiment Station, Biggs, California, are grown on most of the rice acreage in California. These varieties meet some but not all of the objectives of the breeding program.

Wataribune (C.I. 1561)[3] was the leading variety during the first few years that rice was grown in California. It was a long-season, high-yielding, short-grain variety of the Japanese type. In was good in milling quality but matured too late under California conditions.

Caloro was selected at Biggs in 1913 from an introduction received from Japan. This introduction was similar to Wataribune except that it matured about a week to 10 days earlier. Several selections made from this introduction were tested at the Biggs Rice Field Station. One of these selections was increased and released to growers under the name Caloro in 1919. Caloro is a Japanese type, short-grain, partly

---

1 Contribution of the Field Crops Research Branch, Agricultural Research Service, United States Department of Agriculture, and the California Agricultural Experiment Station.

2 Agent (Agronomist), FCRB, ARS, USDA.

3 Refers to the Cereal Accession Number, United States Department of Agriculture - Cereal Crops Section.

awned variety that matures in about 155 days. It is adapted to a wide variety of growing conditions and produces high yields of fair-quality rice. Caloro was grown on about 85 per cent of the California acreage in 1955.

Colusa (C.I. 1600) is an early-maturing, short-grain, awnless variety, selected out of the Italian variety, Chinese Originario, at the Rice Experiment Station, Crowley, Louisiana and released in 1917. It is not well adapted in the South, but it is the leading early-maturing variety in California. It has weak straw and often lodges when the growth is rank and it tillers poorly on previously cropped land. In most years it is lower in yield than Caloro although the milling quality is fairly good. Colusa was grown on about 10 percent of the California rice acreage in 1955.

Calrose was selected out of the Caloro-Calady x Caloro backcross and it was released from the Biggs Station in 1948. It is a medium grain, partly-awned variety, similar to Caloro in growth habit, maturity and yield, but superior to Caloro in quality. Calrose seedlings have difficulty in coming through the water, being inferior to Caloro in this respect. Calrose is grown on about 5 per cent of the California rice acreage. It commands a premium in price over the short-grain (Pearl) varieties in markets where a medium-grain rice is preferred.

Although the rice varieties now available for growing in California are much better adapted than the varieties grown 40 years ago, they lack many of the characteristics needed. The objectives of the breeding investigations are to develop early and mid-season, short- and medium-grain varieties that are tolerant to cold water and to cool weather during flowering and ripening, tiller adequately, do not lodge, respond to fertilizer, and produce high field and mill yields of grain that meet the demands of the trade. An effort is being made to develop these new improved varieties with smooth hulls as this latter characteristic adds to the ease and economy of handling and storing. Additional objectives are to develop long-grain and glutinous varieties that have the other characteristics enumerated above.

The methods being used and the results of some of the experiments to meet these objectives are reported here.

Cold Water Tolerance

The detrimental effect of cold water on stands and yield in rice is well known. In recent years, this problem has become acute in the western portion of the Sacramento Valley, where the major source of irrigation water for rice is the Sacramento River, whose headwaters are now impounded in the Shasta reservoir. Water temperatures now average about 10°F. cooler than before the Shasta dam was built.

Ninety-seven varieties were tested for cold-water tolerance in 1955 in plots adjoining the Glenn-Colusa canal. Average minimum water temperatures did not vary much throughout the nursery, while average maximum temperatures ranged from 65°F.

at the intake box to about 85° at the outlet box. Most of the entries were not headed by September 15 and the varieties that headed were delayed about 1 week on an average.

At present none of the rice varieties grown in the United States have complete tolerance to cold water but certain varieties tested have the ability to come through the water with average minimum temperatures of 65° to 70°F. Few of the varieties emerge when the temperature of the water is below 65°F.

Over 200 varieties received from Hokkaido, Japan, are now being grown in the breeding nursery for observation and increase. These lines will be tested for cold-water tolerance and the better lines will be crossed onto our commercial varieties. This problem is of major importance.

Quality Studies

F_2 plants from backcross made in 1953, involving Caloro and Calrose, were selected for desirable agronomic and grain characteristics. Thirty-five F_3 lines from the above F_2 plants are now being grown and will be tested for milling quality. Samples from some of the F_2 plants of these lines were examined by X-ray to determine whether the presence of fractures in the kernel might be correlated with milling quality.

The varieties in the 1955 yield trials were tested at the USDA Rice Quality Laboratory at the Rice-Pasture Experiment Station at Beaumont, Texas, for milling quality and chemical characteristics. Several short- and medium-grain lines gave high mill yields and low readings in the starch-iodine-blue tests.

About 100 F_5, F_6, and F_7 lines from earlier crosses that appeared uniform and vigorous were harvested in the selection nursery in 1955, and these are being tested for yield, milling quality and other characters in 1956.

Straw Strength

In 1954, four lines from Maratelli (C.I. 8910), a rice variety from Italy, were crossed with Colusa. Maratelli is about 3 weeks earlier and has stiffer straw, less total leaf area, more productive tillers and larger panicles than Colusa. However, Maratelli has a large, coarse kernel that is undesirable from a milling standpoint. About 600 F_3 lines from these crosses are being grown for observation. Plants that have the plant type of Maratelli and the grain type and quality of Colusa will be saved for further experiments.

Smooth Hull Varieties

In 1946 and 1948, some smooth-hull selections were crossed with the three commercial California varieties and with some of the best breeding lines. The hybrid progenies have since been carried on both in bulk and pedigree cultures. The most promising lines having smooth hulls are: 4620A and 4819A (smooth Colusa types); 4617A, 4625A, 484A, and 487A (smooth Caloro types); and 463A (smooth Calrose types).

In 1953, selections from 4819A9 and 4819A10 were backcrossed to Colusa and certain smooth-hull progeny backcrossed to Colusa in 1955. Selected smooth-hull plants from the hybrid family, 4620A, were backcrossed to Colusa in 1955. The best progeny of these backcrosses will be crossed to Maratelli for straw strength in 1957.

Selected plants of hybrid families 484A and 487A were backcrossed to Caloro. The progeny of the backcross will be examined critically this year and the better plants will be grown in pedigree rows in 1957.

The better smooth-hull plants of the Calrose type were backcrossed to Calrose in 1956. A number of the smooth Calrose sorts were noticed in the preliminary yield trials in 1956. Further studies on milling quality and emergence in cold water of the selections of these smooth-Calrose lines will be carried out in 1957.

Comparative yields of the best smooth-hull lines and the commercial varieties in 1954 and 1955 in pounds per acre are as follows:

	1954[1]	1955
Caloro	1374	3039[2]
487A1-12 (Smooth Hull)	1100	3763
Colusa	1813	2819[2]
4819A1-12 (Smooth Hull)	1830	3351
Calrose	2041	3285[2]
4631A1-5 (Smooth Hull)	1502	3337

These preliminary results indicate that the smooth hull lines may yield as well as the rough-hull varieties.

A Long-Grain Rice for California

One of the breeding goals is the development of a long-grain rice adapted to California conditions. The *Indica*-type varieties from the tropics are not hardy enough to withstand the extreme fluctuations in temperature that occur in California. The better long-grain varieties from the Southern States have been crossed with the varieites grown in California. These crosses were made in 1950, 1951 and 1952, and the progeny were studied in 1954 and 1955. Many of the long-grain lines failed to mature in 1954 because of the adverse season. The lines that had the best grain type and the least sterility were saved for testing in 1955. Most of the material was eliminated in 1955 because of late maturity, poor plant type, or poor grain type, although a few long-grained plants were selected from F_3 and F_4 lines for testing in 1956.

Several early lines selected from the cross Rexoro x Red Rice have a desirable plant and grain type. Some of the better

1 The yields of all entries in the yield trials were generally very low due to adverse weather conditions.

2 The yields of the commercial checks are an average of several plots.

lines will be crossed with Caloro. The long-grain varieties are variable in behavior and they yield considerably less than short-grain varieties in California.

Glutinous Varieties

There is not a large demand for glutinous rice in the United States, so only limited work is being done to develop better varieties of this type. However, a number of crosses have been made between glutinous and common varieties. The progeny from these crosses are being tested. Some of the selected hybrids appear to be better than the glutinous varieties now grown in California.

THE USE OF X-RAY AND THERMAL NEUTRONS IN PRODUCING MUTATIONS IN RICE[1]

H. M. Beachell[2]

The use of X-ray and thermal neutrons is being investigated as a means of bringing about favorable mutations in rice varieties. The leading varieties grown in the United States are reasonably well adapted to the various rice growing areas and mechanized production methods. However, mutations bringing about shorter, sturdier straw, earlier maturity, disease resistance and improved milling, processing and cooking quality would be an effective means of improving these varieties.

Materials and Methods :

In 1953, foundation seed lots of Bluebonnet 50 and Century Patna 231 were sent to the Brookhaven National Laboratory, Upton, Long Island, New York, for exposure to X-rays and thermal neutrons. Seed samples of from 50 to 100 grams of each variety were exposed to 15,000, 20,000 and 25,000 r units of X-ray and 16, 20 and 25 hours of thermal neutrons.

The seed from each treated lot and untreated seed were sown at Beaumont, Texas, on May 21, 1953. Where enough were available, 100 plants were selected at random from each treatment of each variety in the fall of 1953. Four panicles were saved from each plant, if available. Seed from 75 plants of each treatment and control plants were sown in single panicle rows on June 1, 1954. By examining the progeny from four panicle rows of each plant, any bud mutations produced would have been readily distinguished. A large number of panicles from the 1954 panicle row test were harvested, and 950 selections were sown in single panicle rows in 1955.

1 *Cooperative investigations of the FCRB, ARS, U.S. Department of Agriculture and the Texas Agricultural Experiment Station.*

2 *Research Agronomist, FCRB, ARS, U.S. Department of Agriculture.*

Results:

First Generation

The lower rates of treatment showed little or no reduction in the number of seedlings that emerged from the soil, but as the rates of treatment increased, there was a marked reduction in seedling emergence. The 25,000 r units of X-ray resulted in a severe reduction in seedling emergence. The 25-hour thermal neutron treatment was even more severe and only an occasional plant survived.

The vegetative growth of plants from seeds receiving the lower rates of treatment appeared normal insofar as could be observed. However, weak or abnormal-appearing plants were apparent as the rates of treatment increased.

All treatments produced many sterile or partly sterile plants and the degree of sterility increased as the rates of treatment increased. Many plants were entirely sterile at the higher rates. The 25-hour neutron treatment was more severe than the 25,000 r unit X-ray treatment. A few plants produced seed in the 25-hour neutron treatment of Bluebonnet 50 but there were no seeds produced in the same treatment of Century Patna 231.

Second Generation

In the X_2 generation, time did not permit a detailed examination of all rows but casual observations were made several times during the vegetative period of growth. An occasional unusual plant was observed in the vegetative stage.

At maturity all rows were examined and panicles of the most apparent mutations were saved. Practically all of the mutations occurred as occasional plants in one or more of the four panicle rows from each X_1 plant.

In some cases a rather large number of abnormal plants were present in the rows, but for the most part the majority of the plants were near normal in appearance, except for varying degrees of sterility. A rather high degree of sterility was apparent throughout the X_2 rows with an increase in degree at the higher rates of treatment.

Third Generation

A total of 950 selections made from X_2 rows was sown in single panicle rows in 1955. This included panicles from untreated material of both varieties. Seventy-two untreated panicle rows of Century Patna 231 and 100 panicle rows of Bluebonnet 50 were sown throughout the experiment. These panicle selections were made at random from the check rows grown in the 1954 experiment.

The types of variability observed in the X_3 rows are recorded in table 1. The most common mutations were in plant height and grain length. Sterility was again pronounced in many of the rows, and 77 rows were recorded as carrying sterile plants of the most severe type. It was estimated that more than 50 per cent of the rows probably showed abnormal sterility.

Grain Length

Occasional plants produced a longer than normal grain, but short grain mutations

were more frequent. The shorter grain types were found mostly on plants of shortened mature height. Both long and short grain mutations were recovered from segregating rows in the X_2 generation. With but one or two possible exceptions, all rows were still segregating for grain length in the X_3 generation.

A short grain mutation was found in Bluebonnet 50, a normally long-grain variety. The height of the plants of this mutation was slightly reduced in comparison with normal plants and the leaves and culms appeared to be slightly wider or thicker.

Hull Color

A rather large number of selections with straw-colored hulls were found in the X_2 and X_3 generations of the Century Patna 231 treatments. It was suggested that these variants were natural crosses. They were found in 4 of the 6 treatments but none were found in the check rows. Only one gold selection was found in Bluebonnet 50, a variety with straw colored hulls.

Plant Height

Most of the mutations involving plant height were shorter than normal but a few plants taller than normal were observed. Many of the shortened plants also had a shortened grain.

One of the most interesting mutations observed was a very short plant which was near normal height in the early vegetative stages. The peduncle elongated to approximately three-fourths normal length, but the other internodes were only slightly elongated. As a result, the plants of this mutant were 12 to 14 inches shorter than normal plants. The panicles and grain appeared to be near normal length. Preliminary yield experiments conducted in 1956 indicate that this mutation is only slightly less productive than normal Century Patna 231.

A somewhat similar mutation was observed in Bluebonnet 50 in which all internodes and the peduncle showed only minor elongation. As a result, most of the panicles failed to emerge from the boot. In some plants the tips of the panicles emerged. Both of these mutations produced normal length grains. Crosses between these mutations and normal plants will be made to determine mode of inheritance for height.

The Bluebonnet 50 treatments produced other mutations 12 to 14 inches shorter than normal with no reduction in grain length. However, in these mutations all internodes elongated but not to the extent as exhibited by normal plants. Many of the short stature mutations appeared to be more susceptible to leaf spot diseases than normal plants.

Rough Hulls

Only two rough-hulled types were recovered in 1955 and both were from Bluebonnet 50. At least one of these had a red seed coat. Several such plants were found in 1954. They resembled natural crosses in that the plants were extremely vigorous.

Shattering

Mutations that shattered freely were found in both varieties in X_2 and were recovered in X_3. They were easily identified since most of the grains had shattered from the panicles when examined. Several shattering plants were present in the X_2 rows.

Narrow Leaf

A plant with extremely narrow leaves, small stems, and short stature was found in an otherwise normal row in the X_2 generation of Century Patna 231. Many normal plants were present in the narrow-leaf X_3 rows in 1955, but most of the narrow-leaf rows were breeding true in 1956. It is suspected that the normals are natural crosses since the plants were very short and completely surrounded by taller, more vigorous plants, which would favor excessive cross pollination in 1953.

Weak or Diseased Plants

Many weak or disease-susceptible plants were found in the X_2 and X_3 generations. Frequently they were completely sterile. A few were recovered in 1955 from similar material found in 1954.

Chlorophyll-Deficient Plants

Several rows of both varieties that were segregating for albino and normal seedlings were found in 1955. This characteristic frequently occurs in rice but the rate of occurrence was possibly increased by the treatment as it was not noted in untreated check rows.

A number of other mutations that have been observed in commercial varieties also were observed. These included characters such as grassy dwarfs, sathi, early maturity, tetraploid-like and others. The X-ray and thermal neutron treatments produced similar variations in most cases and no conclusions were drawn as to whether one was more effective than the other.

Table 1 Mutations Recovered from X_3 Generation of Century Patna 231 and Bluebonnet 50 Varieties of Rice Subjected to X-ray and Thermal Neutron Irradiation, Beaumont, Texas, 1955.

Variety and Type of Mutation	Number of Selections Showing Mutations When Treated With: Thermal Neutrons, hours			X-ray, r units			Total
	16	20	35	15,000	20,000	25,00	
C[1], grain longer	2	0	–	0	1	0	3
B[2], grain longer	3	2	0	0	3	1	8
C, grain shorter	9	0	–	4	3	4	20
B, grain shorter	4	3	1	1	4	2	15

1. C represents Century Patna 231
2. B represents Bluebonnet 50

Variety and Type of Mutation	Number of Selections Showing Mutations When Treated With: Thermal Neutrons, hours 15	20	25	X-ray, r units 15,000	20,000	25,000	Total
C, hull color (straw)	13	1	–	0	2	1	17
B, hull color (gold)	1	0	0	0	0	0	1
C, taller plants	3	0	–	0	4	0	7
B, taller plants	4	1	0	1	1	2	9
C, shorter plants	3	8	–	5	7	7	30
B, shorter plants	27	16	11	10	20	9	93
C, sterile plants	13	10	0	3	0	3	29
B, sterile plants	10	10	6	5	10	7	48
C, rough hulls	0	0	–	0	0	0	0
B, rough hulls	0	1	0	0	0	1	2
C, shattering	0	0	–	0	0	1	1
B, shattering	1	0	1	1	0	1	4
C, narrow leaf	0	0	–	0	1	0	1
B, narrow leaf	0	1	1	0	0	0	2
C, weak or diseased	0	0	–	0	1	1	2
B, weak or diseased	3	4	1	2	1	2	13
C, leaf spot resistant	0	0	–	0	0	0	0
B, leaf spot resistant	0	0	0	0	3	1	4
C, chlorophyl deficient	1	0	–	0	1	4	6
B, chlorophyl deficient	2	0	0	0	0	1	3
C, glutinous	1	0	–	0	1	0	2
C, late plants	1	0	–	1	1	0	3
B, late plants	4	1	1	3	2	3	14
B, early plants	0	0	0	0	0	1	1
B, Tetraploid like	1	1	0	2	0	0	4
B, grassy dwarf	0	0	2	0	0	0	2
B, Sathi	0	0	0	0	0	1	1
B, bearded	0	0	0	0	0	1	1
B, red seed coat	0	1	0	0	0	0	1

A STUDY ON THE RESISTANCE OF RICE TO STEM BORER INFESTATIONS

M.A. Koshairy[1], C.L. Pan[2], Gad El Hak[3]
I. Sirry Abo Zaid, A. Azizi, C. Hindi and M. Masoud[4]

If resistance to stem borer infestation does exist in rice, it would then be much cheaper to control the damage of this insect by breeding for high resistance. In 1953, 1954 and 1956, natural epidemics of stem borer infestation occurred in our breeding nursery, where yield trials consisting of a number of varieties and hyrids were conducted. Although the tests were not originally designed for this purpose, a study was made to determine the reaction of these varieties to bore attack.

Relationship between stem borer infestation and the size of culms

The reactions of 115 varieties grown in 1953 revealed that borer infestation was closely related to the size of culm; the thinner culmed varieties were much less attacked than the thicker culmed ones. It was found that 63 out of 72 varieties with thin and fine culms were only slightly attacked by the borer, while 13 out of 17 varieties with thick culms were moderately or heavily infested. A chi square test for independence confirmed the existence of an association between these two characters.

A genetic study on the nature of the resistance

Two varieties, namely Giza 14 and Sydney A, were found to be quite different in their reaction to borer infestation, the fromer being always only slightly attacked, whereas the latter being always heavily attacked.

In a cross between these two varieties, reactions expressed in percentage of infested plants of several hundred F_2 plants and of the 424 F_3 lines were studied in 1953 and 1954. It was found that the average percentage of infestation of both the F_2 and the F_3 progenies was smaller than their respective mid-parent values, suggesting the presence of some deviations from the pure additive effects.

The frequency distribution of the borer infestation of the 424 F_3 lines was not normal; and the high skewness of the curve with a preponderance of resistant lines indicated that apart from the additive effects of genes, dominance might have also played a part in this cross.

The variance of infestation within the two parents which were grown alongside of

---

1 Director of Plant Breeding Section, Ministry of Agriculture, Cairo, Egypt.

2 FAO Rice Production Expert.

3 Chief of Rice Branch of Plant Breeding Section.

4 Rice Breeders of Rice Branch of Plant Breeding Section.

the F_3 progenies in 1954 was found to be 69.45 per cent which must be all environmental. Since the total variance of the F_3 progenies was found to be 90.23 per cent which is the sum of genotypic variance and environmental variance, the genotypic variance in this cross is equal to 90.28–69.45 = 20.74%. In the broad sense heritability refers to the functioning of the whole genotype as a unit, and could be estimated by dividing the genotypic variance by the total variance. This, in the present case, is equal to 20.74/90.28 = 22.97%. Judging from this comparatively low heritability, it appeared that the resistance to borer infestation in this cross differed in only a few genetic factors.

The data obtained from the foregoing studies have been published in a separate paper elsewhere, and the present review is necesssarily short.

Varietal difference in resistance

In 1956 epidemics of borer infestation occurred in a yield trial where 24 varieties were grown. Each variety was planted in a 5-row plot 3.5 metres long and 1 metre wide with 6 replications, and the 24 varieties were arranged at random in each block.

The number of infested plants was counted in each variety in each block, and then was transformed to the $\sqrt{1/2+X}$ variate, where X refers to the actual number of infested plants in each variety in each block. The data were finally analysed as presented in table 1.

Table I The Analysis of Variance of the Transformed $\sqrt{1/2 + X}$ Variate

Variation due to	*Degree of freedom*	*Mean square*	*F*
Blocks	5	.4603	1.30
Varieties	23	5.9581	16.84
Error	115	.3538	
Total	143	1.2589	

The block mean square was not significantly greater than the error mean square, indicating that the variation between blocks was very small. But variation between varieties was highly significant as indicated by the variety variance being nearly 17 times greater than the error variance, the F value significant at 1 per cent level being approximately equally to 1.94.

From the error variance, as presented in the above table, the least significant difference between any two varieties was found to be 0.66. The average infestation of the 24 varieties in the 6 blocks varied from .88 to 4.28. Yabani Mont. 47, the standard variety most commonly grown by the farmers, had an average infestation of 1.05. Although it ranked second best in this trial, it did not differ significantly from the best variety, which had an average infestation of .88.

Conclusion

1. Varietal difference in resistance to borer infestation has been definitely demonstrated. The standard variety, Yabani Mont. 47 was found to be much less attacked than most of the varieties tested.

2. Resistance to stem borer infestation appeared to be controlled by polygenes, but the number of genes involved appeared to be few. Our results indicated that apart from pure additive effects of genes, dominance might also have played a part in resistance.

3. Stem borer incidence was related to the thickness of rice culms; varieties with thinner culms were attacked less than those with thicker culms.

FISH CULTURE IN RICE FIELDS[1]

Hasnuddin Saanin[2]

Introduction

A good account of fish culture in rice fields was prepared by Mr. W.H. Schuster as a background paper for the 4th Session of the International Rice Commission, held in Tokyo, Japan, in October 1954.

The Commission at its 4th Session, recognizing the economic importance of a combined cultivation of rice and fish in rice fields and considering the advanced methods applied in Japan and Indonesia as useful references for other countries, recommended that member goverments be advised of the desirability of formulating a program of investigation to be undertaken by fisheries and agricultural departments in collaboration and that technical aspects be referred to the Indo-Pacific Fisheries Council.

A Brief Review in Member Countries

The following information was made available to the author as Chairman of the Inland Fisheries Panel of the Indo-Pacific Fisheries Council:

Australia Rice cultivation in the country is highly mechanized and the present practice does not permit fish-stocking in the rice fields.

Burma Fish production in the rice fields is common in the country but it is from wild fish entering the rice fields when flooded. The rate of production is low. In many cases, the farmers, for religious reasons, do not themselves harvest the fish but let out the fishery rights to others.

1. *Condensed from a revised paper prepared for the Fifth Session of the International Rice Commission, held in Calcutta, India, 12-19 November 1956.*

2. *Member of the Indonesian Delegation and Chairman, Inland Fisheries Panel, I.P.F.C.*

Cambodia There is no rice-cum-fish culture in the country as such but, as in most countries of the Far East, a small amount of wild fish is caught from the rice fields.

Ceylon No information available.

France No information available.

India In many rice growing areas in the country, appreciable quantities of wild fish are obtained when the fields are drained. In Andhra State, the rice fields are often used as a source of supply of fingerlings of certain carps that find their way to the fields during the floods. Preliminary experiments indicate that, due to the presence of fish, a 5 to 10 per cent increase in rice production may be possible.

Indonesia Since the Indonesian people readily accept small fish for consumption, raising fish in rice fields is a common practice throughout the country. Fish can be raised either in combination with the growing crop of rice in the field or as a second crop after rice is harvested in places where only one rice crop is grown a year or three rice crops in two years.

Experiments have been and are still being conducted under different soil conditions and with different rice varieties in several parts of the country, to determine the effect of fish culture on the production and quality of rice.

In 1955, it was estimated that 90,000 hectares of rice growing area were used for fish culture in the country.

Italy In the Po plain in Italy carp culture in rice fields is a common practice, especially in Mantova Province. Forty-three per cent of the rice fields were used for this purpose in 1929 and 78-80% in 1953.

Japan In 1956, two kinds of research were started in the country: one to find out the proper relationship between the rice crop and the fish raised in combination; and the other to determine the effect of insecticides on the rice crop and the fish.

For the first kind of investigation, several plots of rice fields were prepared in the usual manner for rice planting but they were stocked with carp and Tilapia in different combinations. The fish were either fed with additional food or lived entirely on the natural growth in the field. It is believed that Tilapia can be used as weed controller in the rice fields. The excess growth of small floating plants on the water surface may keep down the water temperature and thus retard the growth of the rice plant.

For the other investigations, several kinds of insecticides were applied to the rice fields with and without stocking common carp and other species of fish.

Korea No information available.

The Neatherlands No information available.

Pakistan Fish culture in rice fields in the country depends on natural stocking from wild population and the catches reveal a high proportion of predators.

Surveys are now being undertaken to define areas suitable for rice-cum-fish culture.

Philippines Several problems stand in the way of fish culture in rice fields and these

are lack of enough water supply throughout the year; individual farm holdings too big to permit intensive cultivation and lack of suitable fish species for the purpose. Recently species of fish were obtained from Indonesia for experiments.

Taiwan A useful booklet on the culture of Tilapia in rice fields was published by the Chinese-American Joint Commission on Rural Reconstuction in 1953. But since then there has been no further information.

Thailand Fish production in rice fields in Thailand depends on natural stocking at the time when the fields are flooded. Experiments are being conducted in the north to determine suitable species of fish for cultivation in the rice fields.

U.K. Territories

In the *Federation of Malaya*, field trials are in progress on raising Sepat Siam, Carp and Tilapia in rice fields. Early experiments showed an 8 per cent increase in rice production when suitable species were reared with growing rice crop.

In *Hong Kong* experience has shown that carp raising in rice fields is not profitable for the rice grower, largely because of inadequate water supplies and shortage of land, together with the expenses involved in constructing holding grounds for the fish between successive rice plantings.

In *North Borneo* preliminary experiments were begun on a small scale in 1954. No detailed information is yet available.

U.S.A. It was reported that in Arkansas a considerable acreage of rice fields was used for fish raising when the fields were allowed to fallow after a certain period of rice cultivation.

Vietnam No information available.

Problems for Further Investigations

In introducing or promoting rice field fish culture, it seems that the following problems, pertaining to fish and rice culture and socio-economic situations of the rice growers, should be given a careful consideration :

Petaining to fish culture

1. What species are suitable for cultivation in rice fields and how can the stocking material be obtained ?

2. What is the water depth requirement of these species ?

3. What is the proper stocking rate for the different kinds of soil obtaining in the country ?

4. What combination of species can be used and what is the optimal stocking rate of each ?

5. To what size should the fish be raised ?

6. What is the effect of temporary draining of the field and weeding on the growth of the fish ?

7. What is the effect of fertilizers, manure, and insecticides applied on the growth and yield of fish ?

8. What are the possibilities of artificial feeding ?

9. At what range of altitude can fish culture in rice fields be successful ?

Petertaining to rice culture

1. What varieties of rice can stand longer and deeper inundation of the field and thus are suitable for a combined cultivation?

2. What is the effect of fish cultivation on the yield and quality of rice?

3. What is the effect of fish cultivation on the soil-structure of the field and on the growth of aquatic weeds?

4. Is there any effect that fish cultural preparations, including dykes and ditches, may have on the rice crop?

5. What is the effect of fish cultivation as a second crop on the production of rice in the following season?

Pertaining to socio-economic situations of the rice growers

1. Is fish culture in rice fields profitable for the farmers? If so, to what extent?

2. What size of fish is acceptable to the people for table use?

3. How does fish culture in rice fields affect the general economic structure of the local community?

4. Can the farmers meet the extra cost of raising fish in rice fields?

All these problems should be carefully investigated by fisheries and agricultural departments in cooperation.

Printed by Mrs. Prayat Jataputra at Udom Press, New Road, Bangkok. 25/3/2500

REPORTS OF THE COMMISSION AND ITS WORKING GROUPS

Reports of the Commission

Report of the First Session, Bangkok, Thailand, March 1949
Report of the Second Session, Rangoon, Burma, February 1950
Report of the Third Session, Bandung, Indonesia, May 1952
Report of the Fourth Session, Tokyo, Japan, October 1954
Report of the Fifth Session, Calcutta, India, November 1956

Reports of the Working Party on Rice Breeding

Report of the First Meeting, Rangoon, Burma, February 1950
Report of the Second Meeting, Bogor, Indonesia, April 1951
Report of the Third Meeting, Bandung, Indonesia, May 1952
Report of the Fourth Meeting, Bangkok, Thailand, September 1953
Report of the Fifth Meeting, Tokyo, Japan, October 1954
Report of the Sixth Meeting, Penang, Malaya, December 1955

Report of the Working Party on Fertilizers

Report of the First Meeting, Bogor, Indonesia, April 1951
Report of the Second Meeting, Bandung, Indonesia, May 1952
Report of the Third Meeting, Bangkok, Thailand, September 1953
Report of the Fourth Meeting, Tokyo, Japan, October 1954
Report of the Fifth Meeting, Penang, Malaya, December 1955

Report of the ad hoc Working Group on the Problems of Mechanization of Rice Production under Wet Paddy Conditions

Report of the First Meeting, Peradeniya, Ceylon, May 1956

Report of the ad hoc Working Group on the Problems of Storage and Processing of Rice

Report of the First Meeting, Calcutta, India, November 1956

Report of the ad hoc Working Group on the Problems of Soil, Water and Plant Relationships in the Production of Rice

A Preliminary Report by Correspondence, November 1956.

Printed by Mrs. Prayat Jataputra
at Udom Press, New Road, Bangkok.
25/3/2500